Technology Opportunity

Thermophotovoltaic Energy Conversion

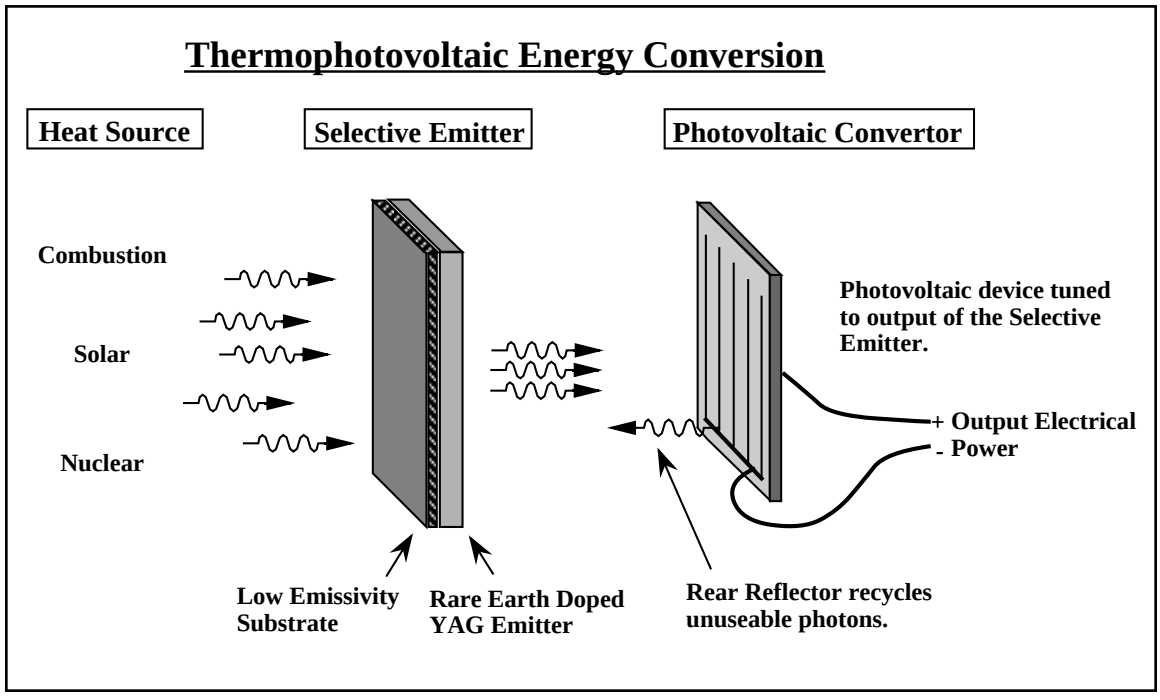
The National Aeronautics and Space Administration (NASA) seeks to transfer the NASA-developed Thermophotovoltaic (TPV) Energy Conversion technology for commercial applications. The technology, developed at Lewis Research Center, is presently being developed for use with the General Purpose Heat Source (GPHS) for deep space missions. TPV is a system for converting heat energy into electrical energy without any moving parts. Suitable heat sources include the combustion of various fuels, concentrated sunlight, and nuclear decay. The heat is coupled to a selective emitter (SE) that emits photons (light) in a very limited spectral band (color) when heated. The emitted light is directed to a solar cell that is specially designed to efficiently convert the incoming light into electricity. NASA seeks a company that is interested in developing this technology for commercial products.

Potential Commercial Uses

- Portable/emergency power supplies
- Hybrid electric vehicles
- Cogeneration—gas furnaces that generate their own electricity
- Utility-scale power generation
- Auxiliary vehicle power (RV, marine)

Benefits

- Quiet operation compared to internal combustion powered systems
- Can use a variety of fuels—provides flexibility in design and operation
- Lower levels of NO_x emissions (compared to internal combustion driven systems) because of lower combustion temperatures and complete combustion of the fuels



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- No vibration
- High reliability and low maintenance owing to the system simplicity and lack of moving parts

The Technology

The specific components of a TPV power system vary, depending upon the heat source utilized and the desired application. All TPV systems consist of three basic elements: (1) a heat source, (2) an emitter, and (3) a photovoltaic array. In addition, recuperators would be incorporated into combustion-driven TPV systems, although they may not be included in cogeneration applications where the waste heat is used for other purposes.

The SE is a rare-earth-doped YAG (yttrium aluminum garnet) crystal with a backing of low emissivity metal to block the broadband radiation produced by the heat source. Heat is conducted through the thin metal substrate to thermally excite the rare-earth dopants in the YAG crystal. Rare earths emit narrow band radiation characteristic of the particular element when excited by heat or light. The SE's demonstrate low emission (emissivity < 0.1) outside the emission band and high emission (emissivity > 0.75) inside the characteristic band. The selection of the rare-earth element depends on the operating temperature of the SE. As the emitter temperature increases, the peak in the available energy shifts to shorter wavelengths (higher energies). Thus, a rare-earth element with an emission band near the peak should be chosen. Photovoltaic cells must be matched to the emission spectrum of the SE. The required bandgaps range from 0.55 to 1.1 eV.

NASA Lewis has developed indium gallium arsenide (InGaAs) photovoltaic devices with bandgaps ranging from 0.55 to 0.75 eV. They are useful for moderate temperature combustor systems.

The cell design (monolithically interconnected module, or MIM) consists of series-interconnected subcells on an electrically insulating substrate. An infrared reflector is added to the rear of the cell to recuperate waste photons. Advantages of the MIM design include improved output power density, simplified system design, and improved reliability.

Options for Commercialization

Researchers at NASA Lewis have developed the critical component technologies required for TPV energy conversion. TPV system development, however, must be specific to the application. Thus we are interested in joining with an industrial partner to develop a TPV system for their particular requirements and application. If your company is interested in Thermophotovoltaic Energy Conversion, or if you desire additional information, please contact us.

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